Application of wastewater recycling in treatment processes

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Abstract. The object of the study is the method of wastewater recycling. The problem of reducing the negative impact on the environment, by increasing the efficiency of treatment facilities is the most urgent at the moment. The methodology of wastewater recycling is one of the most famous and popular, nowadays. Wastewater recycling allows both to reduce the negative impact on the environment and to increase the efficiency of existing technological schemes for wastewater treatment. Examples of the implementation of this method in the meat processing industry, as well as in enterprises producing extraction phosphoric acid and mineral fertilizers, as well as the impact on the operation of biological filters are considered. In the course of the study the current situation in the world on the implementation of this methodology and its effectiveness was considered. Further, both practical and theoretical materials on this issue were considered. The variant of implementation of the recirculation method on the existing technological scheme of wastewater treatment of tannery production was considered. At the end of the study it was concluded that it is important to further investigate this technique for its successful integration into existing wastewater treatment process schemes..

Keywords Wastewater, recycling, climate, industrial effluents, tannery, greenhouse gases

Introduction

The chosen topic of research is conditioned by the importance of environmental conservation. Water is an important element of human life. It is used in all spheres of human activity:household, industrial, agricultural, etc. Water is used for cooking and cultivation of agricultural products, for manufacturing of industrial sector materials and cooling of technological processes, in irrigation processes and production of light industry materials, water treatment processes for urban residents and settlements. Every year the volume of water used increases significantly. According to a UN report [1] they have been increasing by about 1 % every year for the last four decades. This is due to factors such as population increase and socio-economic development. As the consumption of water increases, the percentage of water pollution by the effluents that are generated after its use

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also increases. According to the data for 2022 [2], wastewater is distributed by sectors as follows: housing and communal - 25%, agricultural - 9%, industrial - 63%, other wastewater - 9%. Before discharge into water bodies, all wastewater must be treated to the maximum permissible concentration of harmful substances (MPC) [3]. Wastewater from the industrial sector [4] (tanneries, metallurgical, pulp and paper plants, oil industry enterprises [5]) are among the most polluted in terms of the content of harmful substances. This is due to the complexity of the technological process [6], which requires more and more water every year [7]. To reduce the use of water by industrial enterprises and, consequently, to reduce the formation of wastewater, the technology of recycling or reuse of wastewater [8] is used all over the world. For example, the city of Durban [9], which is the third largest city in South Africa, has been treating and reusing wastewater equivalent to 13 Olympic-sized swimming pools every day since 2001 for the light and refining industries. Wastewater recycling combined with reuse reduces the negative impact on the climate, namely greenhouse gas emissions. In addition, this approach is also cost-effective, as if cities in emerging economies focus on wastewater recycling, after the crisis in 2019, it could mobilise up to $2 trillion in investment and create more than 23 million jobs by 2030. This information demonstrates the effectiveness of this approach, both on the side of reducing negative impacts on the surrounding climate and in terms of job creation. This research paper will examine both existing methods of wastewater recycling and the option of integrating recycling into an existing tannery wastewater treatment process. This will allow to consider the possibility of implementing the discussed technology in other existing technological schemes as well.

Methods

In the course of the study the methods of implementation of wastewater recycling methods at meat processing industry enterprises, enterprises for the production of extractive phosphoric acid and mineral fertilizers, as well as at biofilter were considered. The variants of wastewater recycling method application and their influence on the processes of technological schemes functioning are considered.
Object of study: wastewater treatment.
Research method: wastewater treatment study was used and analyzed to review and examine the existing and most promising applications of the recycling method.
The conclusion is made about the effectiveness of the wastewater recycling method and the possibility of its inclusion in the existing technological schemes.

Results

Application of wastewater recirculation at biological treatment plants [10]. The possibility of application of this method can be conditioned by the following conditions: 1) low degree of wastewater treatment; 2) high degree of pollution content in incoming wastewater; 3) transport of return activated sludge, when used in technological schemes of aeration tanks. Introduction of this method into the existing technological scheme has an impact not only on the efficiency of wastewater treatment, but also on all elements of the system. So at increase or vice versa introduction of wastewater recirculation in biological treatment facilities there is an increase in pressure on them hydraulic load. This value directly depends on the recirculation rate and leads to a change in the duration of stay of wastewater in the biofilter loading, as well as to a better distribution of flowing on the surface of the loading effluent. By introducing recirculation in systems that include aeration tanks, the possibility of increasing the sludge dose and improving the efficiency of wastewater treatment is achieved. However, at the same time there is a reduction of sludge residence time in the sludge separators, which is caused by the increasing hydraulic load. Ultimately, this can lead to increased sludge removal and a significant decrease in the working sludge dose in the aeration tank. Based on the results of this study [10], the following conclusion can be made: the application of wastewater recycling technology can indeed improve the efficiency of wastewater treatment, but to achieve this result, a comprehensive change of the entire system is required.

Application of wastewater recycling technology in the meat processing industry. The composition of wastewater is highly concentrated and contains the following components [11]: a large amount of suspended solids (0.5 - 7 .3 g/dm3), represented by organic impurities and solid insoluble substances; high BOD values (0.2 - 3.0 g/dm3 .); acidity of wastewater varies from very acidic with pH 3.5 to very alkaline with pH 11. In order to improve the efficiency of wastewater treatment, the following process scheme is proposed, which includes the following steps: 1) treatment of coarse-disperse impurities and further disinfection of effluents; 2) dilution of highly concentrated effluents with previously treated ones; 3) complete removal of insoluble sediments. In this case, wastewater recycling helps to achieve the production of the necessary indicators established by the requirements of SanPiN [12] and reduce the negative impact on the environment by diluting highly concentrated wastewater with previously treated wastewater.

Application of recycling technology at enterprises producing extractive phosphoric acid and mineral fertilisers [13]. Wastewaters of this production belong to the 3-4 class of hazard and contain the following components: fluorine (F) in the amount of 0.6 - 4.0 g/dm3 ; phosphorus oxide (P O25) in the amount of 10 - 15 g/dm3 ; suspended solids in the amount from 0.1 to 1.5 g/dm3 . To reduce the negative impact on the environment, the introduction of wastewater recycling technology is proposed: return of part of the sludge to the head of the process, which contributes to increasing the rate of crystallization reaction of phosphorus and fluorine compounds, as well as reducing their concentration in the treated effluent to the level established by the requirements of SanPiN [7]. To prove the effectiveness of this recirculation method, an experiment [8] was conducted on four model solutions that simulated acidic wastewater and sludge produced in the process of its neutralization. Distilled water was used for their preparation in the experiment, the composition of which was adjusted by adding phosphoric and silicofluoric hydrogen acids to achieve fluoride and phosphate concentrations in them. The first solution corresponded to the fluoride effluent produced by absorption. The second solution corresponded to the composition of phosphate-rich effluent coming to the neutralization station from accumulating tanks of phosphogypsum dumps and from the production of mineral salts; the third solution corresponded to the solution after evaporation of acidic effluent coming to the neutralization station. Solution 4 corresponded to a weak solution of phosphoric acid (1% wt. P2 O5) and acted as a comparison solution. The characteristics of the solutions are given in Table 1.

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Table 1 Characteristics of experimental solutions

Indicator name	Modeling Solution			Clarified water after the laboratory thickener
	1	2	3	
pH	0,97	–	–	7,0-8,0
C (F^-), g/dm^3	12,40	1,95	47,35	0,006-0,02
C (P_2O_5), g/dm^3	2,64	9,77	23,08	0,005-0,08
C (s-d, substances), g/dm^3	< 0,100	< 0,100	< 0,100	< 0,100

As a result of the experiment [13] it was found that the organization of the closed scheme of wastewater treatment with recirculation, with the multiplicity factor of sludge circulation
Кц =3, contributed to the reduction of the main controlled indicators (phosphates and fluorides) and provided the neutralization process at lower pH values, which provides a lower consumption of neutralizing agent.

As a result of the analysis of existing systems of wastewater recycling, both in existing systems and in laboratory conditions, we propose the organization of recycling at a tannery located in the territory of the Russian Federation. Further we will consider the existing technological scheme of wastewater treatment of tannery production. Before the production wastewater for treatment, it has the following indicators: pH - 8.09; suspended solids - 1436,3 mg/dm3 , total chromium content - 78,13 mg/dm3 (Chromium 6+ - 3,69 mg/dm3 + Chromium 3+ - 74,55 mg/dm3); COD - 7090,2 mg/dm3 . At the beginning of the treatment process, wastewater enters mechanical treatment to remove suspended solids contained in the effluent. Subsequently, the wastewater enters the horizontal settling tanks for fine mechanical treatment. Thus, the indicators for biological treatment are achieved, the content of suspended solids in the range from 150 to 400 mg/dm3 , pH in the range from 5.5 to 8.5. Nitrification and denitrification are carried out. The final stage of the existing technological scheme is the passage of wastewater through the clarification chamber, where it is further treated. The existing scheme is presented in Figure 1

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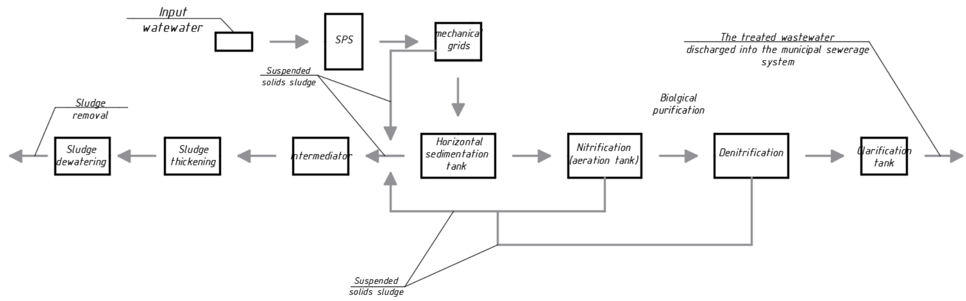

Fig. 1. Existing technological scheme of wastewater treatment

Based on the considered theoretical material, it is supposed to include in the existing technological scheme of wastewater recycling technology: to improve the biological treatment process. Recirculation of effluent after nitrification and denitrification is proposed, which will improve both the efficiency of biological treatment and the efficiency of the technological scheme as a whole. However, based on the considered theoretical material, the introduction of wastewater recirculation leads to a complete change in the technological scheme of treatment, as the hydraulic load on the biological treatment facilities increases, which will require a re-calculation of all structures, along with their geometric dimensions. In order to justify this decision it will be necessary to test the impact of the recirculation method on a laboratory installation.

Figure 2 shows the proposed scheme of wastewater treatment with activated sludge recirculation from the secondary sedimentation tank, which serves as a clarification tank.

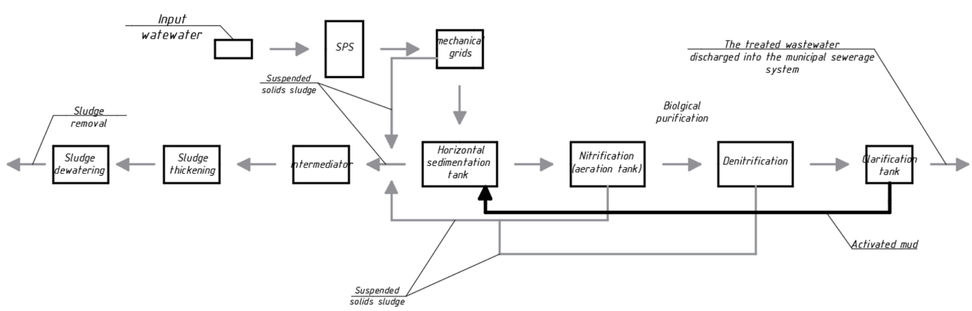

Fig. 2. Assumed technological scheme of wastewater treatment

Conclusions

In the course of this work we have analyzed the methodology of wastewater recycling application, which is implemented in various fields, both in the meat processing industry and in the production of extractive phosphoric acid and mineral fertilizers. Based on the analyzed sources, we can conclude that this technology is widely spread in our country and abroad and is actively used in all industries, from light to heavy. The considered technology really allows reducing the negative impact on the environment and increasing the efficiency of the technological scheme of wastewater treatment as a whole. However, the inclusion of this technique requires a large and serious analysis, which will act as a justification for the necessity and possibility of its implementation, as it entails a complete revision of the technological scheme.

The main conclusion of this research paper is that the problem of improving the efficiency of wastewater treatment in the industrial sector is very important and requires attention. Further research into the inclusion of recycling technology in the existing technological schemes will reduce the negative impact on the environment.

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